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BLUE BABIES AND WELL-WATER

The current interest in the "blue baby" as evidenced by innumerable articles in both the medical and lay press has overlooked the fact that cyanosis in infants frequently is not due to congenital heart disease at all. Transient cyanosis in the newborn is much more often due to prematurity, immaturity and a variety of factors which contribute to an inadequate respiratory effort on the part of the infant. Transient localized cyanosis of vasoparetic etiology is frequently encountered[1].

Continuous cyanosis in an infant has usually been regarded as due to either congenital heart disease or respiratory pathology. Within the last three years many cases of continuous cyanosis in infants have been shown to be due to the ingestion of well-water of high nitrate content used in the preparation of milk formulas. Cases have been reported from Iowa by Comly[2], from Kansas by Faucett and Miller[3], from Belgium by Ferrant[4] and from Western Canada by the author[5-6]. There seems little doubt that this condition is common, that it is frequently not diagnosed correctly and that many if not most of these infants recover spontaneously at about the age of eight to ten weeks. Within the last two years I have encountered more than twice as many cases of well-water methemoglobinemia as of congenital heart disease in infants less than ten weeks of age.

In every reported case the story is the same. The patient is always an infant residing in a rural area. This infant, with a normal birth history does perfectly well as long as it is breast fed. For one reason or another the supply of breast milk fails and the baby is weaned during the first month. A formula is then used, consisting of fresh milk, evaporated milk or dried milk. The water used in the preparation of the feedings is obtained from the well. The amount of water used is greatest when the dried milk formula is used and least in the fresh milk feeding. Within a few days the parents realize that the baby is cyanosed. This cyanosis is continuous and gradually increases in intensity day by day. The baby becomes apathetic, listless and may have attacks of syncope. Careful examination by the doctor reveals no evidence of disease of the heart or lungs. In many cases the doctor assumes the baby has congenital heart disease with no evident murmur. Roentgenograms of the chest show normal cardiac contour, no abnormal mediastinal shadow and no abnormal pulmonary shadows. If a sample of blood is drawn from the infant, it is found to be chocolate colored and examination of the blood in the laboratory with a spectroscope reveals a well-marked methemoglobin band. If a sample of well-water used in the preparation of the feedings is then examined, it is found to have a nitrate content of 100 to 300 parts per million, a figure well above the 10 parts per million considered as a safe upper limit.

The mechanism of the production of methemoglobinemia is not altogether clear. Methemoglobin is normally present in blood to the extent of 1 per cent. It is nontoxic in itself but as it is unable to carry oxygen, cyanosis and even death may result depending on the extent to which hemoglobin is transformed into methemoglobin. In severe cases of well-water methemoglobinemia as much as half of the available hemoglobin is transformed into methemoglobin.

Well-water which is obtained from poorly constructed wells may be contaminated by seepage from manure piles, pigpens, decaying refuse and as a result its nitrate content may rise to high levels. Under ordinary conditions the human body reduces nitrates to nitrites and then to ammonia in which form they are excreted. When a great excess of nitrate is ingested as it is by these tiny infants, the ordinary mechanism evidently breaks down and nitrites are absorbed as such into the circulation. One molecule of nitrite unites with two molecules of hemoglobin to form methemoglobin. In some of the reported cases one-half of the functioning hemoglobin has been replaced by methemoglobin. Cyanosis becomes clinically apparent when one-third of the hemoglobin is replaced by methemoglobin.

No cases have been reported in infants more than 10 weeks of age. Older children drinking water from a well with high content of nitrate are evidently not affected by it. An infant for whom a dried milk formula calling for 30 oz. of water from a contaminated well is used will develop methemoglobinemia. If his formula is changed to an evaporated milk feeding containing only 18 to 20 oz. of water from the same source, his cyanosis will become much less marked but will still be evident. As he reaches the age of 2 months the cyanosis may gradually disappear. All this suggests a relationship between the amount of nitrate ingested and the actual weight of the infant. It is possible also that as the infant grows the mechanism responsible for the conversion of nitrate to nitrite and then ammonia may become efficient so that very little or no nitrite is absorbed into the circulation.

It has been shown experimentally that simple withdrawal of the source of excess nitrate results in almost complete disappearance of the excess methemoglobin in thirty-six hours. This is exactly what occurs clinically in all but the most severe cases if the diagnosis is correctly made and the feedings prepared with safe water of low nitrate content. This fact explains why the diagnosis is so rarely made by doctors or hospitals in larger centers. For example a cyanotic baby of 4 weeks of age is taken to a rural practitioner who suspects but cannot prove the presence of congenital heart disease. The baby is referred to a specialist or clinic in a larger center. Usually the baby is admitted to the hospital. If the diagnosis is not suspected at once, he is sent to the ward for observation and study. His formula is of course made up with city water of good quality. Within twenty-four hours

the cyanosis may be gone or hardly evident and the only way the diagnosis can then be made is to obtain a supply of the suspected well-water and have its nitrate content determined.

This tendency to rapid spontaneous recovery with change of water often leads to erroneous diagnosis. We have the record of one cyanotic baby, 5 weeks old who was referred to a city radiologist for X-radiation of the thymus. The baby arrived in the city from a point some 200 miles distant. A roentgenogram of the chest revealed nothing abnormal but in view of the accompanying instructions, radiation was given. The baby stayed in a city hotel and its formula was of course prepared with city water. The day following radiation treatment the cyanosis had disappeared and the innocent radiologist was the recipient of profuse parental thanks for the miraculous cure. Had the infant not returned home a few days later this case might have gone into the record as a case of thymic enlargement causing cyanosis and cured by radiation. However, this infant did return home and within twenty-four hours was cyanosed again. When water from a more satisfactory well was substituted in the formula, complete and permanent disappearance of the cyanosis resulted. The suspected well-water proved to have a very high content of nitrate.

Congenital heart disease causing cyanosis with no accompanying murmur occurs not infrequently but as stated previously, in my experience it occurs much less frequently than well-water methemoglobinemia. It can be differentiated by evidence of cardiac enlargement or alteration of the normal contour on the roentgenogram or by fluoroscopy. If congenital heart disease of this type is suspected in an infant residing in a rural area, substitution of water from another well may give evidence that leads to the diagnosis. *Certainly any rural infant less than 10 weeks of age who exhibits cyanosis of uncertain etiology should promptly have a change in the water used in preparation of the formula.* If this is not practical, an undiluted acidified milk formula should be used.

As noted before many of these patients require no treatment other than change of the source of water. In cases of more severe disease treatment with methylene blue may be used. Experimentally methylene blue will convert methemoglobin to hemoglobin in ten minutes provided that the methemoglobin content has not risen to more than 40 or 50 per cent of the total pigment. One milligram per kilogram of body weight is given intravenously (0.5 cc. of 1 per cent methylene blue to an 8 pound infant would be a suitable dose). Ascorbic acid, 100 mg. given intramuscularly has also been used with apparent success.

Methemoglobinemia due to the ingestion of well-water of high nitrate content is a preventable disease. There is great need for serious investigation by public health bodies into the state of rural water supplies. There must be hundreds of thousands of old, dilapidated, poorly constructed wells in the United States and Canada. When one considers that in a single year almost 100 cases with a mortality of 10 per cent were reported from a large midwestern state, the urgency of the problem becomes apparent. The actual number of cases is probably much higher since this condition is not reportable and until recently has frequently not been diagnosed correctly. Until such time as the menace of contaminated well-water is removed two measures will serve to lower the incidence of methemoglobinemia. First and foremost the encouragement of breast feeding. When breast milk is not available and mixtures of other types of milk must be used, the water used in their preparation should come from wells known to be free of contamination and preferably certified to contain less than 10 parts per million of nitrate. When a good water supply is not available, mixtures of undiluted acidified milk should be used. It should be borne in mind that boiling contaminated well-water will not materially alter its nitrate content.

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